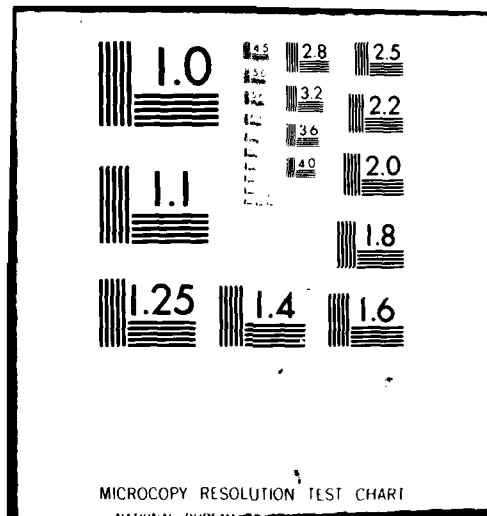


AD-A098 391 ARMY MATERIALS AND MECHANICS RESEARCH CENTER WATERTOWN MA F/6 7/4
POWDER CHARACTERIZATION OF WATERWAYS EXPERIMENT STATION NMFC 19--ETC(U)
FEB 81 N D CORBIN, J W MCCAULEY IAG-WESF-79-288
UNCLASSIFIED AMMRC-TR-81-9 NL

For
AD-A098 391



END
DATE
FILMED
5-81
DTIC



AD A098391

14) AMMRC-TR-81-9

LEVEL II

AD

6) **POWDER CHARACTERIZATION OF
WATERWAYS EXPERIMENT STATION
NMFC 196500 WATER SAMPLES.**

9) *Final rept.,*

10)

NORMAND D. / CORBIN [REDACTED] JAMES W. / McCAULEY
CERAMICS RESEARCH DIVISION

DTIC FILE COPY

11) Feb [REDACTED] 81

12) 23

15)

IAO-WESF-79-58

DTIC
ELECTE

MAY 1 1981

Approved for public release; distribution unlimited.

ARMY MATERIALS AND MECHANICS RESEARCH CENTER
Watertown, Massachusetts 02172

403105

81 5

01 010

mt

The findings in this report are not to be construed as an official Department of the Army position, unless so designated by other authorized documents.

Mention of any trade names or manufacturers in this report shall not be construed as advertising nor as an official indorsement or approval of such products or companies by the United States Government.

DISPOSITION INSTRUCTIONS

Destroy this report when it is no longer needed.
Do not return it to the originator.

UNCLASSIFIED

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

REPORT DOCUMENTATION PAGE		READ INSTRUCTIONS BEFORE COMPLETING FORM
1. REPORT NUMBER AMMRC TR 81-9	2. GOVT ACCESSION NO. AD-A098391	3. RECIPIENT'S CATALOG NUMBER
4. TITLE (and Subtitle) POWDER CHARACTERIZATION OF WATERWAYS EXPERIMENT STATION NMFC 196500 WATER SAMPLES		5. TYPE OF REPORT & PERIOD COVERED Final Report
		6. PERFORMING ORG. REPORT NUMBER
7. AUTHOR(s) Normand D. Corbin and James W. McCauley		8. CONTRACT OR GRANT NUMBER(s)
9. PERFORMING ORGANIZATION NAME AND ADDRESS Army Materials and Mechanics Research Center Watertown, Massachusetts 02172 DRXMR-EO		10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS Intra-Army Order WESRF 79-288
11. CONTROLLING OFFICE NAME AND ADDRESS U.S. Army Engineer Waterways Experiment Station Vicksburg, Mississippi 39180		12. REPORT DATE February 1981
		13. NUMBER OF PAGES 18
14. MONITORING AGENCY NAME & ADDRESS (if different from Controlling Office)		15. SECURITY CLASS. (of this report) Unclassified
		15a. DECLASSIFICATION/DOWNGRADING SCHEDULE
16. DISTRIBUTION STATEMENT (of this Report) Approved for public release; distribution unlimited.		
17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)		
18. SUPPLEMENTARY NOTES		
19. KEY WORDS (Continue on reverse side if necessary and identify by block number) Sediments Water analysis Particle size Emission spectroscopy X-ray spectroscopy Chemical analysis Electron microscopy		
20. ABSTRACT (Continue on reverse side if necessary and identify by block number) (SEE REVERSE SIDE)		

UNCLASSIFIED

SECURITY CLASSIFICATION OF THIS PAGE(When Data Entered)

Block No. 20

ABSTRACT

↓
The particulate matter of thirty water samples collected near the Waterways Experiment Station in Vicksburg, Mississippi, have been characterized. The investigation included ten samples from each of three different locations: the Mississippi River, Yazoo River, and Brown's Lake. Characterization was conducted using particle size distributions, surface areas, scanning electron microscopy, differential thermal analysis, energy dispersive X-ray analysis, X-ray diffraction, and emission spectroscopy. Major differences were noted between all three powder populations.

4

UNCLASSIFIED

SECURITY CLASSIFICATION OF THIS PAGE(When Data Entered)

PREFACE

This final report documents work performed by the Ceramics Research Division of the Metals and Ceramics Laboratory at the Army Materials and Mechanics Research Center, Watertown, Massachusetts, under Intra-Army Order #WESRF 79-288.

The program was administered by the U.S. Army Engineer Waterways Experiment Station in Vicksburg, Mississippi, under technical monitor Dr. K. Thornton. The thirty water samples were collected by Mr. J. Carroll. Also contributing to the work reported herein were Messrs. T. Sheridan (X-ray diffraction), B. Strauss (emission spectroscopy), A. E. Ingram (surface area), A. Connolly (scanning electron microscopy), and C. Bonavita (SEM size analysis).

Accession For	
NTIS GRA&I	<input checked="" type="checkbox"/>
DTIC TAB	<input type="checkbox"/>
Unannounced	<input type="checkbox"/>
Justification	
Distribution/	
Availability Codes	
Avail and/or	
Dist	Special
A	

CONTENTS

	Page
PREFACE.	iii
SUMMARY.	1
OBJECTIVE.	1
APPROACH	
Sample Preparations	1
Physical Characterization	1
Chemical Characterization	3
RESULTS AND DISCUSSIONS	
Physical Characterization	4
Chemical Characterization	11
CONCLUSIONS.	14

SUMMARY

The particulate matter of thirty water samples from the Mississippi River, Yazu River, and Brown's Lake have been characterized. The results are summarized as follows:

Mississippi River - bimodal distribution: 15 wt% averaging 13 μm , 85 wt% averaging $\sim 0.1 \mu\text{m}$; surface area 4.01 m^2/g .

Yazu River - single broad distribution averaging 0.3 μm ; surface area 2.36 m^2/g .

Brown's Lake - bimodal distribution: 10 wt% averaging 11 μm , 90 wt% averaging 0.2 μm ; surface area 8.07 m^2/g .

OBJECTIVE

To characterize particulates in NMFC 196500 water samples: 30 samples, ten each from the Mississippi River (MR-1 to MR-10), Yazu River (YR-1 to YR-10), and Brown's Lake (BL-1 to BL-10).

APPROACH

Sample Preparations

All 30 samples had to be dried in order to perform the required analysis. The following procedure was used:

- 1) pipetting off all but 20 ml of water from the settled samples, leaving the undisturbed sediment at the bottom of the jars;

- 2) shaking, to mix, the remaining 20 ml of water and sample;

- 3) pouring the mixed sample into a drying dish;

- 4) rinsing the jar with about 10 ml of distilled water and also pouring into the drying dish;

- 5) drying in an oven at 90°C for about 8 hours or until the sediment is thoroughly dried; and

- 6) breaking the dried sample, which is in the form of large thin sheets, with a spatula.

Some tests required combining several samples together to provide enough material for the test. Table 1 shows which samples were analyzed for each test.

Physical Characterization

Particle Size Distribution

Particle size distributions of each sample was determined with a Sedigraph (5000D, Micromeritics Instrument Corporation).

Table 1. WATERWAYS EXPERIMENT STATION

Sample	Sedigraph Traces	Surface Area°	SEM	Emission Spec°	XRD	DTA°
<u>BL</u>						
1	x					
2	x		x			
3	x	x		x		x
4	x				x	
5	x	x		x		x
6	x	x		x		x
7	x	x		x		x
8	x	x		x		x
9	x	x		x		x
10	x					
<u>YR</u>						
1	x					
2	x		x			
3	x	x		x		x
4	x				x	
5	x	x		x		x
6	x	x		x		x
7	x	x		x		x
8	x	x		x		x
9	x	x		x		x
10	x					
<u>MR°</u>						
1 }	x	x	x	x		x
2 }						
3 }	x				x	
4 }						
5 }	x	x		x		x
6 }						
7 }	x	x		x		x
8 }						
9 }	x	x		x		x
10 }						

°Samples combined for analysis

Most samples were run separately in the Sedigraph; however, MR samples had to be doubled up to obtain enough material for analysis. The samples were very difficult to disperse in water with the result that the initial data was affected by problems with flocculation and agglomeration of particles. The following procedure was adopted which produced very good results.

1) A surfactant consisting of a 0.1 weight percent solution of sodium pyrophosphate in deionized water was used.

2) The sample and solution were mixed with a magnetic stirrer for approximately 20 minutes.

3) The mixtures were then further diluted with the surfactant to near the limit of Sedigraph sensitivity in order to remedy flocculation problems.

4) The sample and solution mixture was put into an ultrasonic bath for 20 minutes.

5) A solution of NaOH was added until the mixture pH was about 10.5.

6) The mixture was reagitated for an additional 10 minutes in an ultrasonic mixer.

To use the Sedigraph a value for the density of the particles making up the samples must be known. We assumed a value of 2.60 g/cc, because it was thought to be representative of the average density for alpha quartz and clay materials.

Surface Area

The surface area was determined by the multiple point BET method.¹ The samples were prepared by drying as previously described. Several samples had to be combined to obtain enough sediment for an accurate surface area determination.

Scanning Electron Microscopy (SEM)

In order to observe individual particles under the SEM, a *very* dilute solution of each sample had to be specially prepared, using the same technique as for the Sedigraph analysis. This resulted in the breakdown of the large, agglomerated dry fragments. A drop of this solution was then placed on a warmed SEM sample holder. The water was allowed to evaporate, leaving a fairly well dispersed sediment sample. This sample was then coated with a thin (~ 400 Å) gold-palladium alloy to prevent charge buildup on the sample.

The frequency percent by number histogram distributions were derived from photographs of the samples at 2000X. The method for measuring the distribution used several different photographs of each sample and an overlay grid. The size of the particle at regular grid intervals was recorded with up to 100 counts taken on each photograph.

Chemical Characterization

Emission Spectroscopy

Semiquantitative emission spectroscopy was conducted on all three sediment samples. The samples for emission spectroscopy were dried, as previously described, and consisted of mixtures of several samples.

X-Ray Diffraction

X-ray diffraction analysis was performed by using $\text{CuK}\alpha$ radiation with a nickel filter, setting the sensitivity to 500 cps and starting at a two theta angle of five degrees. In all cases the samples were smear mounted on glass slides. (Recessed plastic holders were tried but the results were of poor quality.)

SEM Energy Dispersive X-Ray Analysis

The preparations of samples for this analysis are identical to the SEM sample preparation.

Using energy dispersive X-ray analysis (EDAX) on the scanning electron microscope, semiquantitative chemical analyses were obtained on individual particles within the samples. Two measurements were made on each sample: one on a large particle and the other on the fine matrix phase.

1. BRUNAUER, S., EMMETT, P. H., and TELLER, E. *The Adsorption of Gases in Multi-Molecular Layers*. J. Am. Chem. Soc., v. 60, 1938, p. 309.

The measurements are recorded as electron volts (energy of characteristic X-rays) versus counts, with the energy levels yielding unambiguous elemental analysis, while their relative concentrations are obtained by peak (count) height measurements. The characteristic voltages (eV) of the following elements were used in the analysis: 1.48 Al, 1.73 Si, 2.10 K, 6.30 Fe, and 7.95 Cu. Other elements, 2.0 eV Au and 2.75 eV Pd, were present due to their use in sample preparation.

Differential Thermal Analysis

Differential thermal analysis (DTA) was carried out using a DuPont 990 Thermal Analyzer. A sample weight of 0.03 g (30 mg) was used with a heating rate of 5°C/min against an $\alpha\text{Al}_2\text{O}_3$ reference sample of similar weight. The samples were heated from room temperature to 940°C to trace any organic peaks occurring in the sample. Upon reaching 940°C the furnace was allowed to cool to 400°C. The sample was then reheated to 700°C. For this second heating the instrument sensitivity was increased to observe the weak alpha-to-beta quartz transformation peak at ~600°C.

RESULTS AND DISCUSSIONS

Physical Characterization

Macroscopic Characterization

The as-received samples contain some fairly large [>0.1 mm (100 μm)] fragments of multicolored material. These fragments appeared stringy in nature and clogged up the tubing used for particle size analysis. When dried, the samples had brown to gray color tones with the MR samples darkest and BL samples the lightest. Under low-power (100X) magnification, the samples appeared to have large, clear particles with sharp corners lying on brown powdery material. The possibility of two different phases, each having a different size, became immediately apparent.

Particle Size Distribution

Figure 1 illustrates the experimental range (experimental variation) of results obtained on all samples. The data are plotted as cumulative mass percentage less than a particular size versus log of equivalent spherical diameter. The effects of Brownian motion are pronounced for particles less than 1.0 μm , making the experimental variation of results for these particles noticeably larger. Roughly 25 wt% of all samples had an equivalent spherical diameter (ESD) ~ 0.1 μm . None of the samples had particles larger than 40 μm .

Other graphical representations were produced using an average distribution for each sediment sample. By taking the slope along the average cumulative mass percent curves [$\Delta \text{wt}\% \div \Delta \log \text{ESD} (\mu\text{m})$], a frequency curve can be obtained as shown in Figure 2. Figure 3 presents lognormal plots of the three samples, using an average of the original Sedigraph data. The straight lines show the populations within each sample if lognormal distributions are assumed. The idealized coarse and fine population lognormal distribution lines are calculated in the following way: the actual frequency distribution median values and standard deviations are iteratively estimated from the frequency distribution until idealized frequency distribution curves closely approximate the actual data.

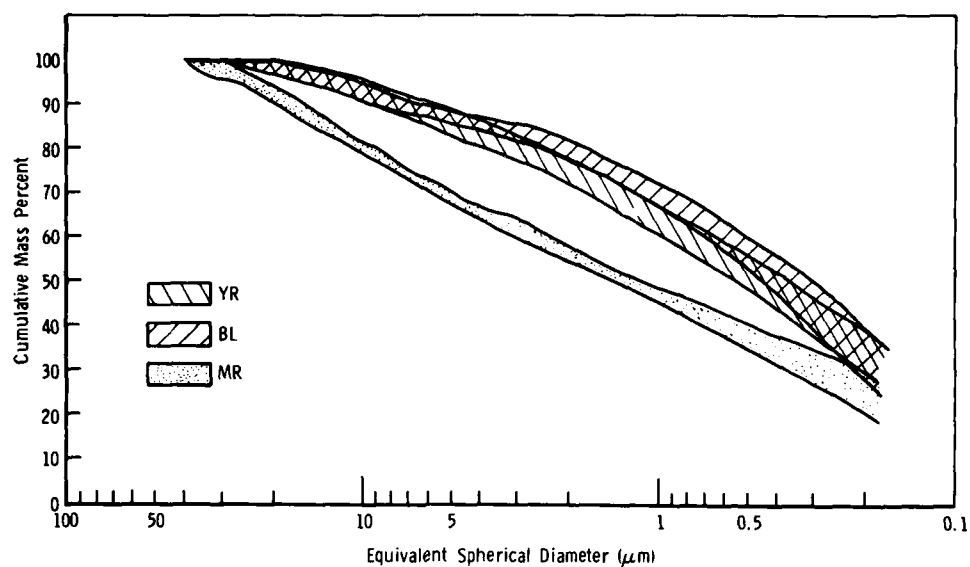


Figure 1. Ranges of X-ray Sedigraph traces of WES samples.

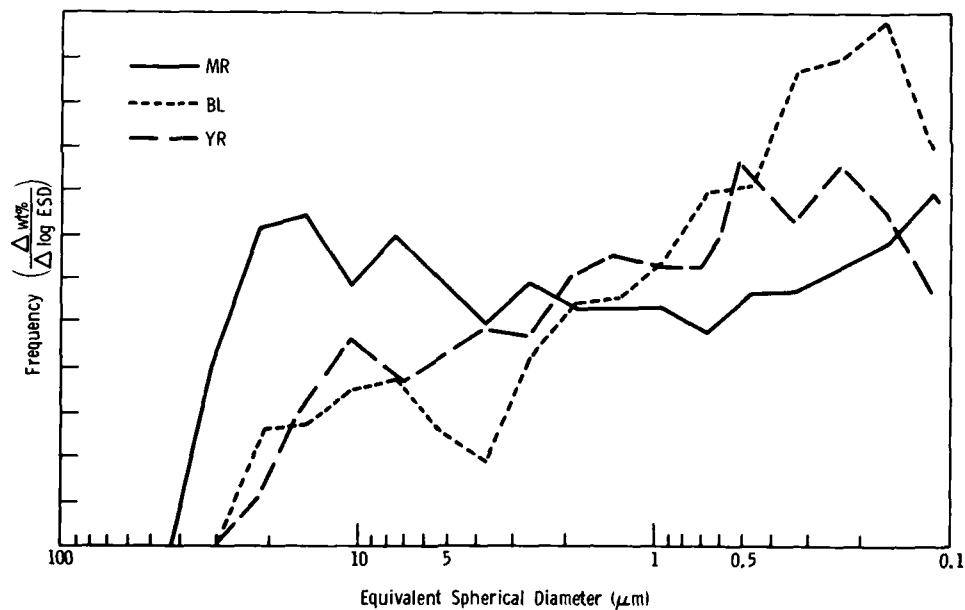


Figure 2. Unsmoothed frequency distribution curves calculated from Sedigraph traces.

Using the lognormal distribution equations (presented in Table 2), and the *idealized* lognormal population means and standard deviations (Table 3), a smooth frequency distribution plot can be determined (Figure 4). This matches very well with the frequency plot from the raw data (Figure 2).

The idealized Sedigraph results, summarized in Table 3, clearly show differences between all three samples. Samples MR and BL contain two distinct populations: coarse fractions having medians about 11 μm and fine fractions with medians of about 0.2 μm .

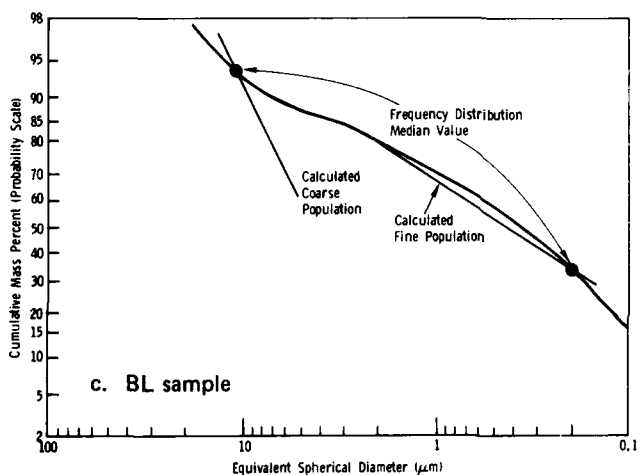
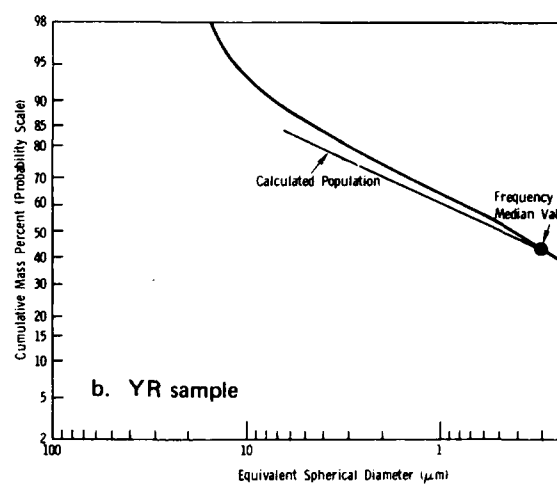
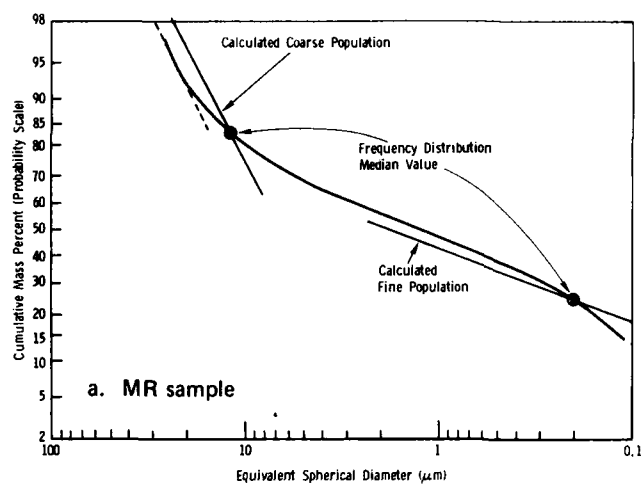


Figure 3. Actual and calculated lognormal distributic samples plotted on log-probability paper.

Table 2. LOGNORMAL PARAMETERS AND EQUATIONS

$d_g(c)$ = geometric median diameter for coarse population
 $d_g(f)$ = geometric median diameter for fine population
 $\sigma_g(c)$ = geometric standard deviation for coarse population
 $\sigma_g(f)$ = geometric standard deviation for fine population
 $f(c)$ = weight fraction of sample in coarse population
 $f(f)$ = weight fraction of sample in fine population
 $f(c) + f(f) = 1$

1) Normal Gaussian distribution equation:

$$f(x) = \frac{1}{\sigma \sqrt{2\pi}} \exp \left[-\frac{(x-\mu)^2}{2\sigma^2} \right]$$

2) Lognormal Gaussian distribution equation used for analysis of powders less than 100 μm :

$$f(x) = \frac{1}{(\log \sigma_g) \sqrt{2\pi}} \exp \left[-\frac{(\log d_g)^2}{2(\log \sigma_g)^2} \right]$$

3) Lognormal bimodal Gaussian distribution equation used for analysis of powders less than 100 μm :

$$f(x) = \frac{f(c)}{(\log \sigma_g(c)) \sqrt{2\pi}} \exp \left[-\frac{(\log d_g(c))^2}{2(\log \sigma_g(c))^2} \right] + \frac{f(f)}{(\log \sigma_g(f)) \sqrt{2\pi}} \exp \left[-\frac{(\log d_g(f))^2}{2(\log \sigma_g(f))^2} \right]$$

Table 3. SUMMARY OF SEDIGRAPH RESULTS

	Mode 1			Mode 2		
	$d_g(c)$	$\sigma_g(c)$	Percent of Sample*	$d_g(f)$	$\sigma_g(f)$	Percent Sample
BL	11 μm	1.78	10	0.2 μm	6.3	90
YR				0.3 μm	15.85	100
MR	12 μm	1.99	15	0.2 μm	19.95	85

*Estimated

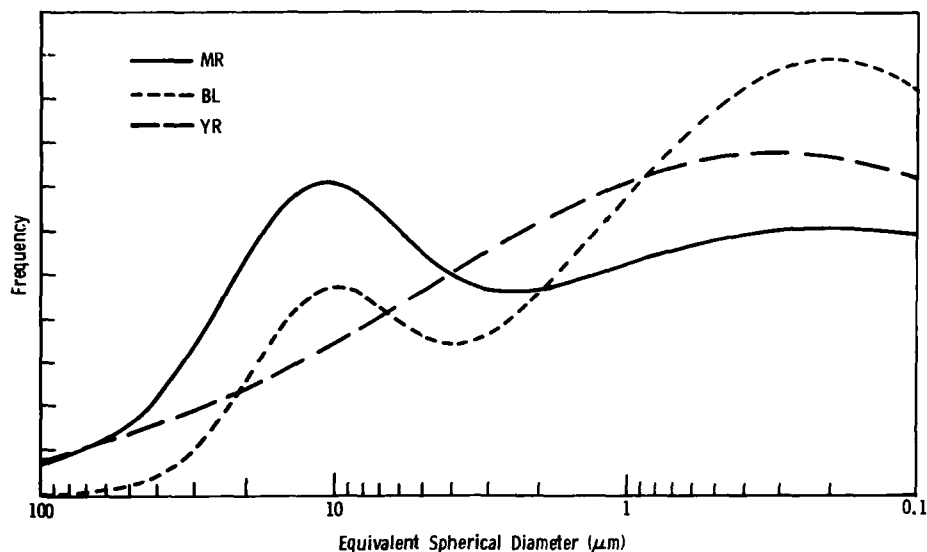


Figure 4. Idealized lognormal frequency distribution curves.

The YR sample appears to have only one very broad population present, with a median value of 0.3 μm . These idealized results, however, are slightly different from data extracted from Figure 2. From this figure the following results are deduced:*

BL: two populations: 10 wt% averaging 11 μm ; 90 wt% averaging $\sim 0.16 \mu\text{m}$;

YR: single broad distribution averaging 0.3 μm ; and

MR: two populations: 15 wt% averaging 13 μm ; 85 wt% averaging $\sim 0.1 \mu\text{m}$ (the experimental limit of the Sedigraph).

Surface Area

The surface area results are given in Table 4. Ideal spherical diameters assuming a density of 2.6 g/cc were calculated and are also listed in the table. Interpretation of surface area values of multimode populations is extremely difficult. At first glance the results do not seem to compare with the Sedigraph data; however, closer inspection of Figure 4 reveals reasonable rationale. The high surface area of the BL sample can be ascribed to the large population of the fine fraction as compared to the other two.

Table 4. SURFACE AREA DATA

	S_w (m^2/g)	d (S_w^*), μm	X-Ray Sedigraph	
			d_g (f), μm	Percent of Population
BL	8.07	0.286	0.2	90
YR	2.36	0.977	0.3	100
MR	4.01	0.576	0.2	85

*Equivalent spherical diameter assuming 100% monospheres and $\rho = 2.6 \text{ g/cc}$

*The percentages are deduced from the total area under the curve, not from relative peak heights.

The MR sample has a relatively large fraction of larger size particles, suggesting a low surface area; however, the large amount of the $<0.1 \mu\text{m}$ material contributes significantly to the total surface area. The surface irregularity (deviation from sphericity) of the individual particles can also significantly affect the results.

SEM Analysis

Scanning electron microscopy (SEM) photographs ranging in magnifications from 20X to 10,000X are shown in Figures 5, 6, and 7. The 1,000X magnification photographs

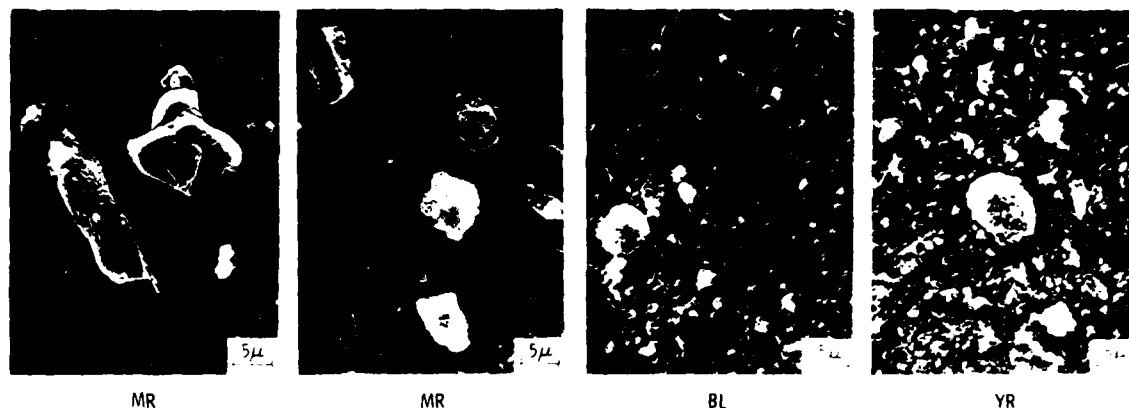


Figure 5. SEM photographs of large particles.

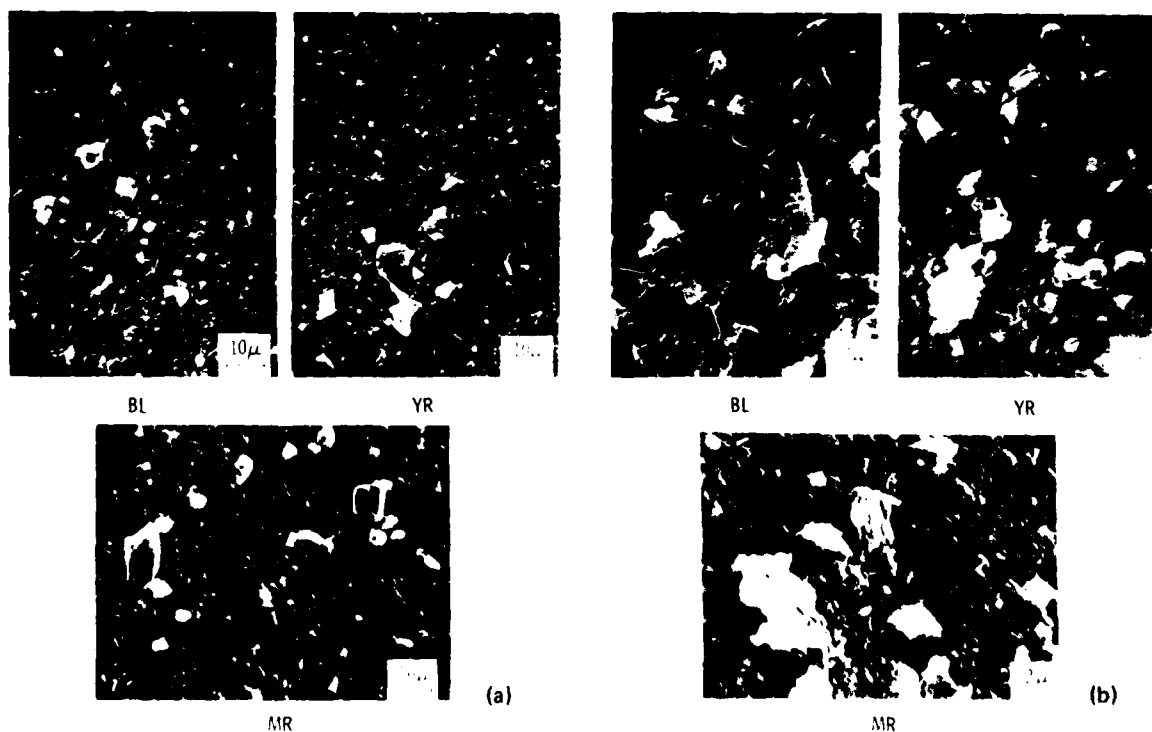


Figure 6. SEM photographs of matrices.

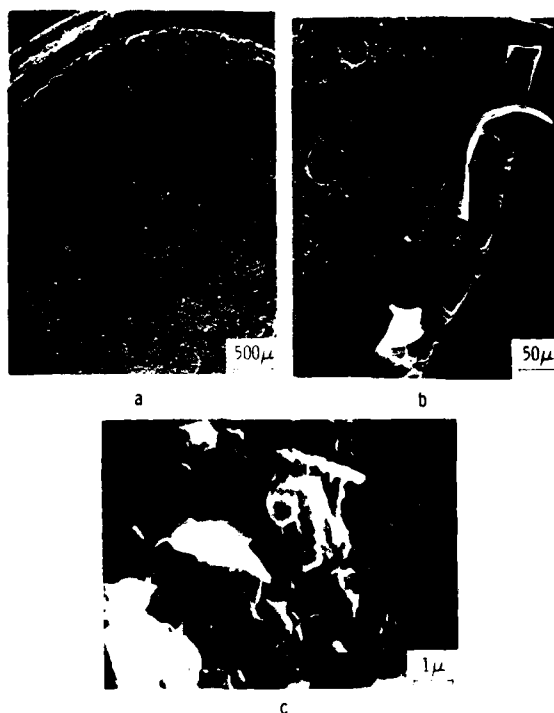


Figure 7. MR sample (a); YR sample showing organic rim (b); and MR sample showing platy structure of matrix (c).

(Figure 6a) show the MR sample containing larger particles ($\sim 12 \mu\text{m}$) than BL or YR. The MR sample also appears to have two very distinct populations present, one having particles near $10 \mu\text{m}$ while the other contains particles less than $0.1 \mu\text{m}$, confirming the Sedigraph results. The BL and YR samples also contain particles over a broad range of sizes, with the largest being $10 \mu\text{m}$. These two samples contain more intermediate sized particles, near $4 \mu\text{m}$, than MR, which gives them a coarser appearance. Figure 6b shows 5,000X photographs of the matrix phase for each sample.

The platy structure of particles in the $1\text{-}\mu\text{m}$ size range can be readily observed in Figure 7c. The 200X photograph (Figure 7b) shows the outer cracked rim which forms when the sample is prepared. It is presumed the rim contains predominantly organic matter from the sample.

The large particles in Figure 5 are determined to be quartz by energy-dispersive X-ray analysis. Particle size distributions were determined by using the SEM photographs. Figure 8 presents histograms plotted as the number percent of particles in a size range versus particle diameter. The frequency block at $0.2 \mu\text{m}$ represents all particles counted that were less than this value. Again the multimode characteristics of the powder distribution can be observed. MR has the largest percent of particles less than $0.2 \mu\text{m}$, while BL has the largest percent of particles in the $1.0\text{-}\mu\text{m}$ range. All three samples show two populations present, one near $1.5 \mu\text{m}$ and the other at less than $0.2 \mu\text{m}$.

Comparison of these histograms to the Sedigraph frequency distribution plots in Figure 4 reveal an interesting relationship, often overlooked. While the microscope particle size distributions frequency is in number percent, the Sedigraph distribution

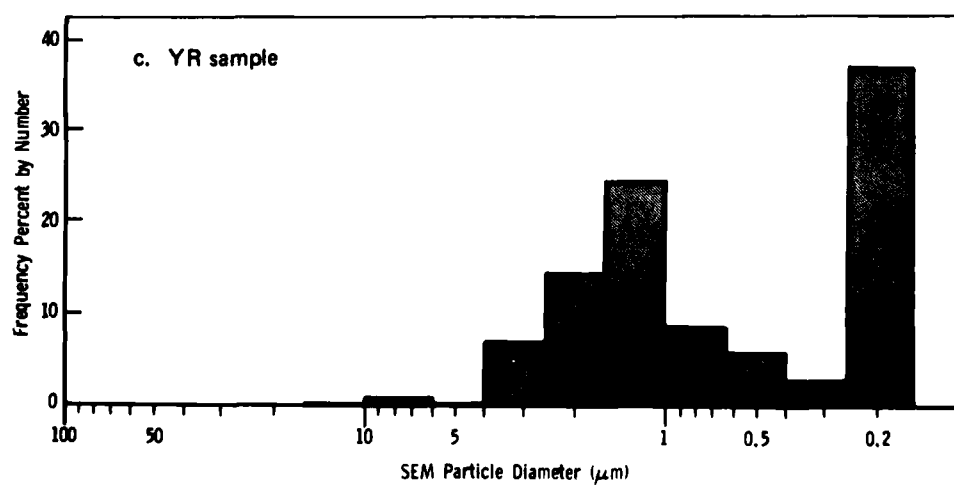
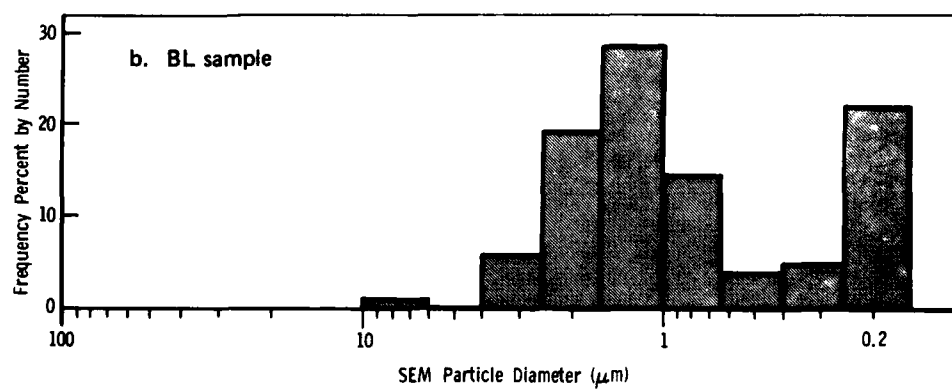
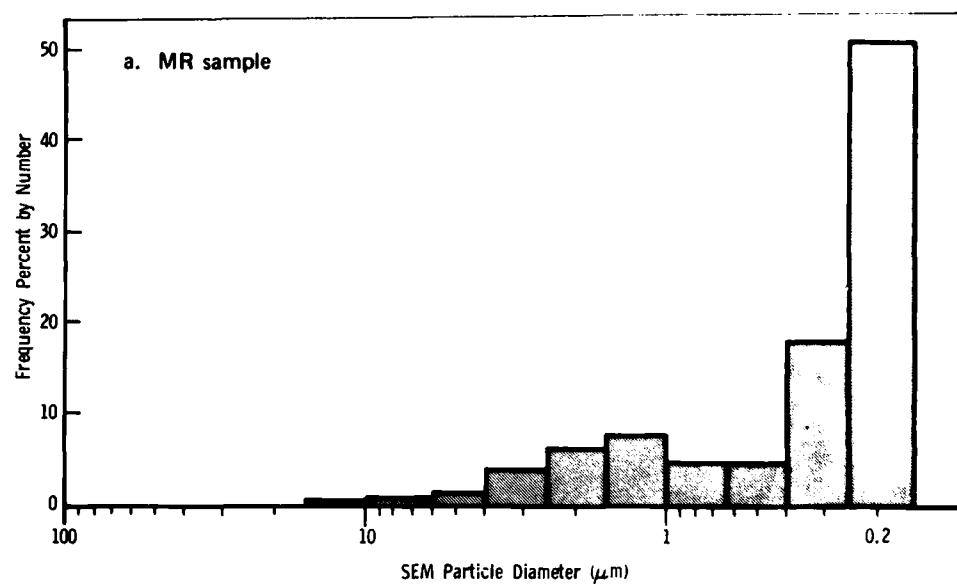


Figure 8. Histograms of percent by number from SEM of samples.

is in terms of weight percent. The weight percent distribution can easily be converted into a number percent distribution, assuming ideal lognormal single-mode distribution. In these terms, the microscope and Sedigraph distributions agree within reasonable limits. The following example will illustrate this point: assume a population of 1001 spheres consisting of one 10- μ m particle and a thousand 1- μ m particles. The total weight of the small particles is equal to the weight of the single large particle. Therefore, the coarse fraction makes up 50% by weight of the sample. In the number percent calculation, the large particle is counted only once so it makes up only 0.1% by number of the sample.

Chemical Characterization

Emission Spectroscopy

Semiquantitative emission spectroscopy results on all three samples are listed in Table 5. No major differences were noted in the major chemistry. Silicon, iron, and aluminum are the major elements, while calcium, magnesium, and sodium also significantly contribute to the overall chemistry. Differences appear to consist of BL and MR being higher in calcium, whereas BL has more sodium than YR and MR.

X-Ray Diffraction

The BL sample appeared to be the least crystalline material, due to few non-alpha quartz diffraction peaks. Table 6 lists the approximate relative intensities and d-spacings for the samples. Phase identification was assisted by the JCPDS*-Johnson/Vand Powder Diffraction Search/Match Computer Program. The results are listed in Table 7. Alpha quartz (SiO_2) was the most abundant crystalline phase present in all

Table 5. SEMIQUANTITATIVE
EMISSION SPECTROSCOPY*

	BL	YR	MR
Si	>10	>10	>10
Fe	5-10	5-10	5-10
Al	~5	~5	~5
Ca	1-5	~1	~5
Mg	1-5	1-5	1-5
Na	~5	~1	~1
Ba	~0.5	~0.5	~0.5
Ti	~0.5	~0.5	~0.5
W	~0.5	~0.5	~0.5
Mn	0.1-0.5	~0.1	0.1-0.5
B	~0.05	~0.01	~0.05
Cr	~0.05	~0.05	~0.05
Cu	~0.05	~0.05	~0.05
Ni	~0.05	~0.05	~0.05
V	~0.05	~0.05	~0.05

*Approximate weight percent of total sample

Table 6. X-RAY POWDER DIFFRACTION DATA

BL		YR		MR	
d, Å	I	d, Å	I	d, Å	I
13.291	41	14.418	25	14.096	7
10.464	26	10.282	3	10.282	6
7.138	10	7.036	16	7.025	8
4.216*	12	4.928	8	6.237	6
3.548	16	4.193*	16	4.955	3
3.326*	100	3.534	20	4.418	7
2.447*	15	3.311*	100	4.210*	24
1.991*	10	3.140	20	3.986	6
1.812*	10	2.441*	7	3.312*	100
		2.269*	6	3.175	13
		1.976*	10	3.089	7
		1.811*	12	2.969	5
		1.666	8	2.876	5
		1.537*	10	2.557	8
		1.372*	8	2.442*	17
				2.270*	10
				2.225*	7
				2.115*	8
				1.973*	8
				1.811*	19
				1.664*	10
				1.537*	15
				1.469*	6
				1.372*	17

* αSiO_2 (PDF #5-0490)

*Joint Committee on Powder Diffraction Standards, 1601 Park Lane, Swarthmore, PA 19081.

samples. Analysis of remaining non-SiO₂ peaks revealed at least two other phases: one a chlorite-type clay and the other difficult to determine accurately. The percentages of each phase present are only estimates due to possible preferred orientation of the clay particles and the presence of noncrystalline clays and organics.

Energy-Dispersive X-Ray Analysis

Energy-dispersive X-ray analysis results are listed in Table 8. Figure 9 is an example of the EDAX analysis. In all samples the matrix has an Al/Si ratio from 10 to 100 while the large particle ratio is much smaller, 0.2 to 3.0. Although this analysis was conducted on a very small number (certainly not a representative sample) of large particles, some tentative conclusion can be made. The large particles in the BL material are predominantly quartz, whereas the high aluminum content of the YR large particle may mean the presence of corundum or altered plagioclase feldspar. The large particulates in MR could be made up of quartz and altered orthoclase feldspar.

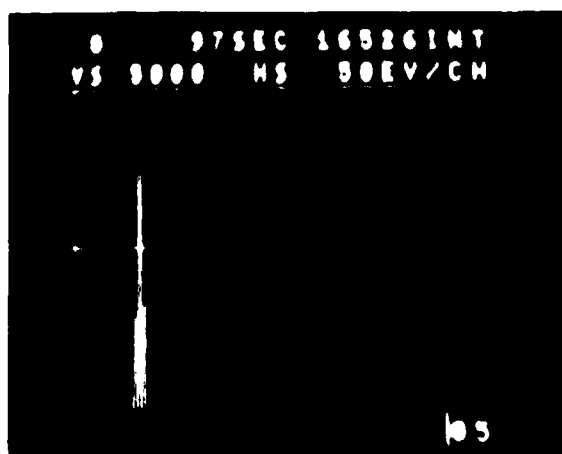
Table 7. X-RAY DIFFRACTION COMPUTER-ASSISTED ANALYSIS

BL	65%	Alpha Quartz	SiO ₂
	35%	Chlorites (Polygorskite, Bavalite)	(Fe, Mg, Al) ₅ Si ₄ Al ₁₈ O ₂₀ (OH) ₂ ·XH ₂ O
YR	70%	Alpha Quartz	SiO ₂
	15%	Zeolite(?) (Gismondine)	Ca(Al ₂ Si ₂ O ₈)·4 H ₂ O
	15%	Chlorites (Polygorskite, Bavalite)	(Fe, Mg, Al) ₅ Si ₄ Al ₁₈ O ₂₀ (OH) ₂ ·XH ₂ O
MR	80%	Alpha Quartz	SiO ₂
	9%	Montmorillonite	Na _{0.38} (Al _{1.67} Mg _{0.33})Si ₄ O ₁₀ (OH) ₂
	11%	Chlorites (Polygorskite, Bavalite)	(Fe, Mg, Al) ₅ Si ₄ Al ₁₈ O ₂₀ (OH) ₂ ·XH ₂ O

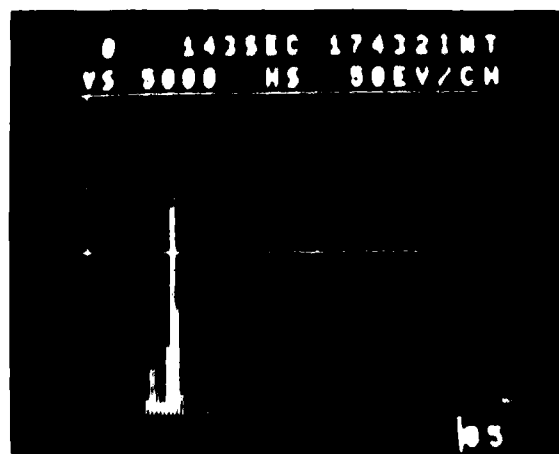
Table 8. NONDISPERSIVE X-RAY ANALYSIS*

	BL		YR		MR	
	Large Particle	Matrix	Large Particle	Matrix	Large Particle	Matrix
Al	1.5	8.0	6.5	7.2	3.1	9.5
Si	7.0	0.4	2.0	0.7	3.8	-
K	0.4	-	0.1	-	1.2	-
Fe	-	0.1	0.1	0.1	-	-
Cu	-	0.1	0.1	0.1	-	0.1
Al/Si	0.214	20.0	3.25	10.3	0.816	>100

*Peak heights in arbitrary units - relative quantities



a. BL sample - large particle



b. BL sample - matrix material

Figure 9. Energy-dispersive X-ray analysis.

Differential Thermal Analysis

Since clay materials differ in their characteristic DTA curves, this method of analysis was chosen to aid in determination of the clay phases. The resulting traces are shown in Figure 10. These samples have very different patterns than expected. Clays typically have several endothermic peaks, one at low temperatures due to water loss and one near 570°C due to a dehydroxylation reaction. However, as seen in the diagram, no endothermic peaks seem to occur, only exothermic. The exothermic peaks are due to burning organic materials within the sample. These reactions are strong enough to overwhelm any possible clay peaks. Unaltered carbonaceous remains (algal remains and/or peaty components) burn out between 300°C and 350°C. At 380°C volatile components are liberated from organics while at 500°C free carbon burns.²

The alpha-to-beta quartz transformation peak was obtained by reheating the sample after the organics were burned off. The occurrence of this peak implies that the samples probably contain at least two crystalline phases, quartz and an unidentifiable clay material. From these scans we are able to obtain the relative amounts of organics within each sample. The MR sample contains the most organics and YR the least.

Since in the absence of air we could not obtain the exothermic peaks due to carbonaceous oxidation, several scans were run in an argon atmosphere. These results provided no further information.

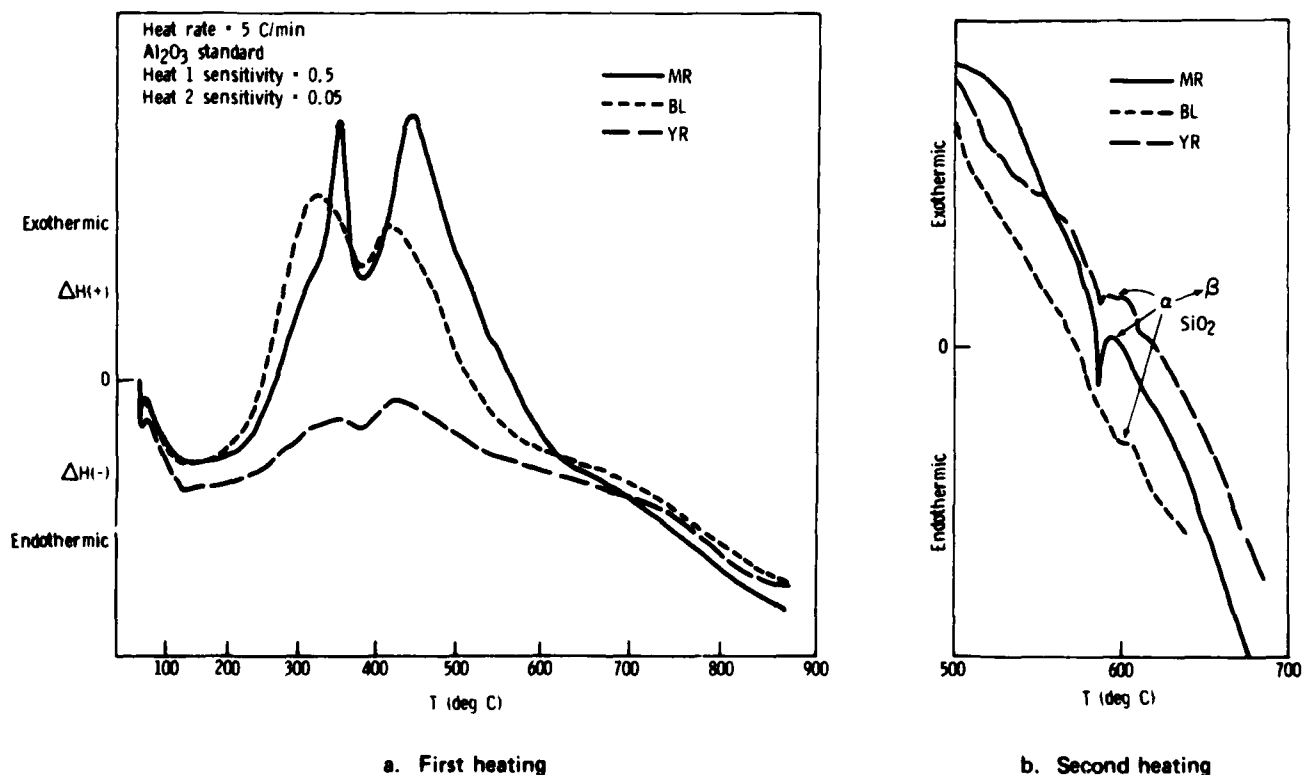


Figure 10. DTA scans.

- GRIMSHAW, R. W., and ROBERTS, A. L. *Carbonaceous Materials, Chapter XVI* in *Differential Thermal Investigation of Clays*, Robert C. MacKenzie, ed., London Mineralogical Society (Clay Minerals Group), 1966, p. 404-417.

CONCLUSIONS

Table 9 summarizes the conclusions detailed below.

Table 9. SUMMARY OF RESULTS

Population	BL	YR	MR
	2 Modes	1 Broad Mode	2 Modes
Large Fraction			
Population, %	10	-	15
Median Size, μm	11	-	13
Width	1.78	-	1.99
Composition	Quartz	Quartz and Corundum	Quartz and Orthoclase Feldspar
Fine Fraction			
Population, %	90	100	85
Median Size, μm	0.2	0.3	< 0.1
Width	6.3	15.85	19.95
Composition	Clay	Clay	Clay
Surface Area, sq m/g	8.07	2.36	4.01
Organic Matter	Intermediate	Least	Largest

The Brown's Lake sample is bimodally distributed with 10 wt% of the total particulate population being large, nearly spherical quartz grains having a median size of 11 μm and the remaining 90 wt% consisting of a very broad distribution of an iron-rich chlorite-like clay with a median size near 0.2 μm . Differential thermal analysis suggests the presence of a fairly large quantity of carbonaceous material. X-ray diffraction analysis also indicates that the clay phase is poorly crystallized or X-ray amorphous.

The Yazu River material is a broadly distributed powder with a median near 0.3 μm . The larger size fraction is predominantly quartz with smaller amounts of corundum or altered plagioclase feldspar, while the very fine particles are essentially a poorly crystallized chloritic clay material. This sample contains a much larger proportion of particles in the 1- to 5- μm range than the other two (BL and MR) populations. It also contains the least amount of organic matter.

The Mississippi River sample also has a bimodal distribution. Fifteen weight percent of the total population consists of irregularly shaped quartz or altered orthoclase feldspar grains with a median size of 13 μm , while the remaining 85 wt% is a fine montmorillonite or chlorite-type clay with a median size of less than 0.1 μm . The SEM analysis clearly shows that there is a more discernible size difference between the large and fine fractions of this material than the other two samples. This sample also contains the most organic matter and clay phases which exhibit X-ray diffraction patterns suggesting a more crystalline material.

DISTRIBUTION LIST

No. of Copies	To	No. of Copies	To
1	Office of the Under Secretary of Defense for Research and Engineering, The Pentagon, Washington, D.C. 20301	1	Commander, U.S. Army Armament Research and Development Command, Dover, New Jersey 07801
1	ATTN: Mr. J. Persh	1	ATTN: Mr. J. Lannon
1	Dr. J. Gamota	1	Dr. G. Vezzoli
12	Commander, Defense Technical Information Center, Cameron Station, Building 5, 5010 Duke Street, Alexandria, Virginia 22314	1	Mr. A. Graf
1	National Technical Information Service, 5285 Port Royal Road, Springfield, Virginia 22161	1	Mr. Harry E. Peibly, Jr., PLASTECH, Director Technical Library
1	Director, Defense Advanced Research Projects Agency, 1400 Wilson Boulevard, Arlington, Virginia 22209	1	Commander, U.S. Army Armament Materiel Readiness Command, Rock Island, Illinois 61299
1	ATTN: Dr. A. Bement	1	ATTN: Technical Library
1	Dr. Van Reuth	1	Commander, Aberdeen Proving Ground, Maryland 21005
1	MAJ Harry Winsor	1	ATTN: DRDAR-CLB-PS, Mr. J. Vervier
1	Battelle Columbus Laboratories, Metals and Ceramics Information Center, 505 King Avenue, Columbus, Ohio 43201	1	Commander, U.S. Army Mobility Equipment Research and Development Command, Fort Belvoir, Virginia 22060
1	ATTN: Mr. Winston Luckworth	1	ATTN: DRDME-EM, Mr. W. McGovern
1	Dr. D. Niesz	1	DRDME-V, Mr. E. York
1	Dr. R. Willis	1	DRDME-X, Mr. H. J. Peters
1	Deputy Chief of Staff, Research, Development, and Acquisition, Headquarters, Department of the Army, Washington, D.C. 20310	1	Director, U.S. Army Ballistic Research Laboratory, Aberdeen Proving Ground, Maryland 21005
1	ATTN: DAMA-ARZ	1	ATTN: DRDAR-TSB-S (STINFO)
1	DAMA-CSS, Dr. J. Bryant	1	Commander, Rock Island Arsenal, Rock Island, Illinois 61299
1	DAMA-PPP, Mr. R. Vawter	1	ATTN: SARRI-EN
1	Commander, U.S. Army Medical Research and Development Command, Fort Detrick, Frederick, Maryland 21701	1	Commander, U.S. Army Test and Evaluation Command, Aberdeen Proving Ground, Maryland 21005
1	ATTN: SGRD-SI, Mr. Lawrence L. Ware, Jr.	1	ATTN: DRSTE-ME
1	Commander, Army Research Office, P.O. Box 12711, Research Triangle Park, North Carolina 27709	1	Commander, U.S. Army Foreign Science and Technology Center, 220 7th Street, N.E., Charlottesville, Virginia 22901
1	ATTN: Information Processing Office	1	ATTN: Military Tech, Mr. W. Marley
1	Dr. G. Mayer	1	Chief, Benet Weapons Laboratory, LWSL, USA ARRADCOM, Watervliet, New York 12189
1	Dr. L. Hunt	1	ATTN: DRDAR-LCB-TL
1	Commander, U.S. Army Materiel Development and Readiness Command, 5001 Eisenhower Avenue, Alexandria, Virginia 22333	1	Commander, Watervliet Arsenal, Watervliet, New York 12189
1	ATTN: DRCOMD-ST	1	ATTN: Dr. T. Davidson
1	DRCLDC	1	Director, Eustis Directorate, U.S. Army Mobility Research and Development Laboratory, Fort Eustis, Virginia 23604
1	Commander, U.S. Army Electronics Research and Development Command, Fort Monmouth, New Jersey 07703	1	ATTN: Mr. J. Robinson, SAVOL-E-MOS (AVRADCOM)
1	ATTN: DELSD-I	1	Mr. E. Walker
1	Commander, U.S. Army Materiel Systems Analysis Activity, Aberdeen Proving Ground, Maryland 21005	1	Commander, U.S. Army Engineer Waterways Experiment Station, Vicksburg, Mississippi 39180
1	ATTN: DRXSY-MF, H. Cohen	1	ATTN: Research Center Library
1	Commander, U.S. Army Night Vision Electro-Optics Laboratory, Fort Belvoir, Virginia 22060	1	U.S. Army Munitions Production Base Modernization Agency, Dover, New Jersey 07801
1	ATTN: DELNV-S, Mr. P. Travesky	1	ATTN: SARPM-PBM-P
1	DELNV-I-D, Dr. R. Buser	1	Technical Director, Human Engineering Laboratories, Aberdeen Proving Ground, Maryland 21005
1	Commander, Harry Diamond Laboratories, 2800 Powder Mill Road, Adelphi, Maryland 20781	1	ATTN: Technical Reports Office
1	ATTN: Mr. A. Benderly	1	Chief of Naval Research, Arlington, Virginia 22217
1	Technical Information Office	1	ATTN: Code 471
1	DELHD-RAE	1	Dr. A. Giness
1	Commander, U.S. Army Missile Command, Redstone Arsenal, Alabama 35809	1	Dr. R. Potanka
1	ATTN: Mr. P. Ormsby	1	Naval Research Laboratory, Washington, D.C. 20375
1	Technical Library	1	ATTN: Dr. J. M. Krafft - Code 5830
1	DRSMI-TB, Redstone Scientific Information Center	1	Mr. R. Rice
1	Commander, U.S. Army Aviation Research and Development Command, 4100 Goodfellow Boulevard, St. Louis, Missouri 63120	1	Dr. Jim C. I. Chang
1	ATTN: DRDAV-EXT	1	Headquarters, Naval Air Systems Command, Washington, D.C. 20360
1	DRDAV-QE	1	ATTN: Code 5203
1	Technical Library	1	Code MAT-42M
1	Commander, U.S. Army Natick Research and Development Command, Natick, Massachusetts 01760	1	Mr. L. Marshall
1	ATTN: Technical Library	1	Headquarters, Naval Sea Systems Command, 1941 Jefferson Davis Highway, Arlington, Virginia 22376
1	Dr. J. Hanson	1	ATTN: Code 135
1	Commander, U.S. Army Satellite Communications Agency, Fort Monmouth, New Jersey 07733	1	Headquarters, Naval Electronics Systems Command, Washington, D.C. 20360
1	ATTN: Technical Document Center	1	ATTN: Code 504
1	Commander, U.S. Army Tank-Automotive Research and Development Command, Warren, Michigan 48090	1	Commander, Naval Ordnance Station, Louisville, Kentucky 40214
1	ATTN: Dr. W. Bryzik	1	ATTN: Code 85
1	Mr. E. Hamperian	1	Commander, Naval Material Industrial Resources Office, Building 537-2, Philadelphia Naval Base, Philadelphia, Pennsylvania 19112
1	Dr. Rose	1	ATTN: Technical Director
1	DRDTA-PXA, Dr. J. Chevalier		
1	DRDTA-UL, Technical Library		
1	DRDTA-P		

No. of Copies	To
1	Commander, Naval Weapons Center, China Lake, California 93555 ATTN: Mr. F. Markarian Mr. E. Teppo Mr. M. Ritchie
1	Commander, U.S. Air Force of Scientific Research, Building 410, Bolling Air Force Base, Washington, D.C. 20332 ATTN: MAJ W. Simmons
1	Commander, U.S. Air Force Materials Laboratory, Wright- Patterson Air Force Base, Ohio 45433 ATTN: Dr. N. Tallan Dr. H. Graham Dr. R. Ruh Mr. K. S. Mazdiasni Aero Propulsion Labs, Mr. R. Marsh
1	Commander, Air Force Weapons Laboratory, Kirtland Air Force Base, Albuquerque, New Mexico 87115 ATTN: Dr. R. Rudder
1	Commander, Air Force Armament Center, Eglin Air Force Base, Florida 32542 ATTN: Technical Library
1	National Aeronautics and Space Administration, Washington, D.C. 20546 ATTN: Mr. G. C. Deutsch - Code RW Mr. J. Gangler AFSS-AD, Office of Scientific and Technical Information
1	National Aeronautics and Space Administration, Lewis Research Center, 21000 Brookpark Road, Cleveland, Ohio 44135 ATTN: J. Accurio, USAMRD Dr. H. B. Probst, MS 49-1 Dr. R. Ashbrook Dr. S. Dutta Mr. C. Blankenship
1	National Aeronautics and Space Administration, Langley Research Center, Hampton, Virginia 23665 ATTN: Mr. J. Buckley, Mail Stop 387
1	Commander, White Sands Missile Range, Electronic Warfare Laboratory, OMEW, ERADCOM, White Sands, New Mexico 88002 ATTN: Mr. Thomas Reader, DRSEL-WLM-ME
1	Department of Energy, Division of Transportation, 20 Massachusetts Avenue, N.W., Washington, D.C. 20545 ATTN: Mr. George Thur (TEC) Mr. Robert Schulz (TEC) Mr. John Neal (CLNRT) Mr. Steve Wander (Fossil Fuels)
1	Department of Transportation, 400 Seventh Street, S.W., Washington, D.C. 20590 ATTN: Mr. M. Lauriente
1	Mechanical Properties Data Center, Belfour Stulen Inc., 13917 W. Bay Shore Drive, Traverse City, Michigan 49684
1	National Bureau of Standards, Washington, D.C. 20234 ATTN: Dr. S. Wiederhorn Dr. J. B. Wachtman
1	National Research Council, National Materials Advisory Board, 2101 Constitution Avenue, Washington, D.C. 20418 ATTN: Dr. W. Prindle D. Groves R. M. Spriggs
1	National Science Foundation, Washington, D.C. 20550 ATTN: B. A. Wilcox
1	Admiralty Materials Technology Establishment, Polle, Dorset BH16 6JU, United Kingdom ATTN: Dr. D. Godfrey Dr. M. Lindley
1	AiResearch Manufacturing Company, AiResearch Casting Company, 2525 West 190th Street, Torrance, California 90505 ATTN: Mr. K. Styhr Dr. D. Kotchick
1	AiResearch Manufacturing Company, Materials Engineering Dept., 111 South 34th Street, P.O. Box 5217, Phoenix, Arizona 85010 ATTN: Mr. D. W. Richerson, MS 93-393/503-44 Dr. W. Carruthers
1	AYCO Corporation, Applied Technology Division, Lowell Industrial Park, Lowell, Massachusetts 01887 ATTN: Dr. T. Vasilos

No. of Copies	To
1	Carborundum Company, Research and Development Division, P.O. Box 1054, Niagara Falls, New York 14302 ATTN: Dr. J. A. Coppola
1	Case Western Reserve University, Department of Metallurgy, Cleveland, Ohio 44106 ATTN: Prof. A. H. Heuer
1	Ceradyne, Inc., P.O. Box 11030, 3030 South Red Hill Avenue, Santa Ana, California 92705 ATTN: Dr. Richard Palicka
1	Combustion Engineering, Inc., 911 West Main Street, Chattanooga, Tennessee 37402 ATTN: C. H. Sump
1	Cummins Engine Company, Columbus, Indiana 47201 ATTN: Mr. R. Kamo
1	Defence Research Establishment Pacific, FMO, Victoria, B.C., VOS 1B0, Canada ATTN: R. D. Barer
1	Deposits and Composites, Inc., 1821 Michael Faraday Drive, Reston, Virginia 22090 ATTN: Mr. R. E. Engdahl
1	Electric Power Research Institute, P.O. Box 10412, 3412 Hillview Avenue, Palo Alto, California 94304 ATTN: Dr. A. Cohn
1	European Research Office, 223 Old Marylebone Road, London, NW1 - 5th, England ATTN: Dr. R. Quattrone LT COL James Kennedy
1	FMC Corporation, 1105 Coleman Avenue, Box 1201, San Jose, California 95108 ATTN: Dr. A. E. Gorum, Manager of Advanced Technology Ordnance Engineering Division
1	Ford Motor Company, Turbine Research Department, 20000 Rotunda Drive, Dearborn, Michigan 48121 ATTN: Mr. A. F. McLean Mr. E. A. Fisher Mr. J. A. Mangels Mr. R. Govilla
1	General Atomic Company, P.O. Box 81608, San Diego, California 92138 ATTN: Jim Halzgraf
1	General Electric Company, Mail Drop H-99, Cincinnati, Ohio 45215 ATTN: Mr. Warren Nelson
1	General Electric Company, Research and Development Center, Box 8, Schenectady, New York 12345 ATTN: Dr. R. J. Charles Dr. C. D. Greskovich Dr. S. Prochazka
1	General Motors Corporation, AC Spark Plug Division, Flint, Michigan 48556 ATTN: Dr. M. Berg
1	Georgia Institute of Technology, EES, Atlanta, Georgia 30332 ATTN: Mr. J. D. Walton
1	GTE Laboratories, Waltham Research Center, 40 Sylvan Road, Waltham, Massachusetts 02154 ATTN: Dr. C. Quackenbush Dr. W. H. Rhodes
1	IIT Research Institute, 10 West 35th Street, Chicago, Illinois 60616 ATTN: Mr. S. Bortz, Director, Ceramics Research Dr. D. Larsen
1	Institut fur Werkstoff-Forschung, DFVLR, 505 Porz-Wahn, Linder Hohe, Germany ATTN: Dr. W. Bunk
1	Institut fur Werkstoff-Forschung, DFVLR, 5000 Koln 90(Porz), Linder Hohe, Germany ATTN: Dr. Ing Jurgen Heinrich
1	International Harvester, Solar Division, 2200 Pacific Highway, P.O. Box 80966, San Diego, California 92138 ATTN: Dr. A. Metcalfe Ms. M. E. Gulden

No. of Copies	To
1	Jet Propulsion Laboratory, C.I.T., 4800 Oak Grove Drive, Pasadena, California 91103 ATTN: Dr. Richard Smoak
1	Kawecki Berylco Industries, Inc., P.O. Box 1462, Reading, Pennsylvania 19603 ATTN: Mr. R. J. Longenecker
1	Martin Marietta Laboratories, 1450 South Rolling Road, Baltimore, Maryland 21227 ATTN: Dr. J. Venables
1	Massachusetts Institute of Technology, Department of Metallurgy and Materials Science, Cambridge, Massachusetts 02139 ATTN: Prof. R. L. Coble 1 Prof. H. K. Bowen 1 Prof. W. D. Kingery 1 Prof. R. Cannon
1	Materials Research Laboratories, P.O. Box 50, Ascot Vale, VIC 3032, Australia ATTN: Dr. C. W. Weaver
1	Midwest Research Institute, 425 Volker Boulevard, Kansas City, Missouri 64110 ATTN: Mr. Gordon W. Gross, Head, Physics Station
1	Norton Company, Worcester, Massachusetts 01606 ATTN: Dr. N. Ault 1 Dr. M. L. Torti
1	Pennsylvania State University, Materials Research Laboratory, Materials Science Department, University Park, Pennsylvania 16802 ATTN: Prof. R. Roy 1 Prof. R. E. Newnham 1 Prof. R. E. Tressler 1 Prof. R. Bradt 1 Prof. V. S. Stubican
1	Pratt and Whitney Aircraft, P.O. Box 2691, West Palm Beach, Florida 33402 ATTN: Mr. Mel Mendelson
1	PSC, Box 1044, APO San Francisco 96328 ATTN: MAJ A. Anthony Borges
1	RIAS, Division of the Martin Company, Baltimore, Maryland ATTN: Dr. A. R. C. Westwood
1	Rockwell International Science Center, 1049 Camino Dos Rios, Thousand Oaks, California 91360 ATTN: Dr. F. Lange
1	Royal Aircraft Establishment, Materials Department, R 178 Building, Farnborough, Hants, England ATTN: Dr. N. Corney
1	Shane Associates, Inc., 7821 Carrleigh Parkway, Springfield, Virginia 22152 ATTN: Dr. Robert S. Shane, Consultant
1	Silag Inc., P.O. Drawer H, Old Buncombe at Poplar Greer, South Carolina 29651 ATTN: Dr. Bryant C. Bechtold
1	Solar Turbine International, 2200 Pacific Coast Highway, San Diego, California 92138 ATTN: Mr. Andrew Russel, Mail Zone R-1
1	Stanford Research International, 333 Ravenswood Avenue, Menlo Park, California 94025 ATTN: Dr. P. Jorgensen 1 Dr. D. Rowcliffe

No. of Copies	To
1	State University of New York at Stony Brook, Department of Materials Science, Long Island, New York 11790 ATTN: Prof. Franklin F. Y. Wang
1	TRW Defense and Space Systems Group, Redondo Beach, California 90278 ATTN: Francis E. Fendell
1	United Technologies Research Center, East Hartford, Connecticut 06108 ATTN: Dr. J. Brennan 1 Dr. F. Galasso
1	University of California, Department of Materials Science and Engineering, Hearst Building, Berkeley, California 94720 ATTN: Dr. D. Clarke
1	University of California, Lawrence Livermore Laboratory, P.O. Box 808, Livermore, California 94550 ATTN: Mr. R. Landingham 1 Dr. C. F. Cline
1	University of Florida, Department of Materials Science and Engineering, Gainesville, Florida 32601 ATTN: Dr. L. Hench
1	University of Massachusetts, Department of Mechanical Engineering, Amherst, Massachusetts 01003 ATTN: Prof. K. Jakus 1 Prof. J. Ritter
1	University of Newcastle Upon Tyne, Department of Metallurgy and Engineering Materials, Newcastle Upon Tyne, NE1 7 RU, England ATTN: Prof. K. H. Jack
1	University of Washington, Ceramic Engineering Division, FB-10, Seattle, Washington 98195 ATTN: Prof. James I. Muller
1	Virginia Polytechnic Institute, Department of Materials Engineering, Blacksburg, Virginia 24061 Prof. D. P. H. Hasselman
1	Westinghouse Electric Corporation, Research Laboratories, Pittsburgh, Pennsylvania 15235 ATTN: Dr. R. J. Bratton 1 Dr. B. Rossing
1	Mr. Joseph T. Bailey, 3M Company, Technical Ceramic Products Division, 3M Center, Building 207-1W, St. Paul, Minnesota 55101
1	Dr. Jacob Stiglich, Dart Industries/San Fernando Laboratories, 10258 Norris Avenue, Pacoima, California 91331
1	Dr. J. Petrovic - CMB-5, Mail Stop 730, Los Alamos Scientific Laboratories, Los Alamos, New Mexico 87545
1	Mr. R. J. Zentner, EAI Corporation, 198 Thomas Johnson Drive, Suite 16, Frederick, Maryland 21701
1	Dr. Howard Mizuhara, GTE-WESGO, 477 Harbor Boulevard, Belmont, California 94002
1	Mr. Edward Kraft, Product Development Manager, Industrial Sales Division, Kyocera International, Inc., 8611 Balboa Avenue, San Diego, California 92123
2	Director, Army Materials and Mechanics Research Center, Watertown, Massachusetts 02172 ATTN: DRXMR-PL 1 DRXMR-WD 2 Authors

Army Materials and Mechanics Research Center,
Watertown, Massachusetts 02172
POWDER CHARACTERIZATION OF WATERWAYS
EXPERIMENT STATION NMFC 196500 WATER
SAMPLES - Normand D. Corbin and
James W. McCauley

Technical Report AMMRC TR 81-9, February 1981, 18 pp -
illus-tables, Intra-Army Order MESRF 79-288

The particulate matter of thirty water samples collected near the Waterways Experiment Station in Vicksburg, Mississippi, have been characterized. The investigation included ten samples from each of three different locations: the Mississippi River, Yazoo River, and Brown's Lake. Characterization was conducted using particle size distributions, surface areas, scanning electron microscopy, differential thermal analysis, energy dispersive X-ray analysis, X-ray diffraction, and emission spectroscopy. Major differences were noted between all three powder populations.

AD
UNCLASSIFIED
UNLIMITED DISTRIBUTION
Key Words

Sediments
Water analysis
Particle size

Army Materials and Mechanics Research Center,
Watertown, Massachusetts 02172
POWDER CHARACTERIZATION OF WATERWAYS
EXPERIMENT STATION NMFC 196500 WATER
SAMPLES - Normand D. Corbin and
James W. McCauley

Technical Report AMMRC TR 81-9, February 1981, 18 pp -
illus-tables, Intra-Army Order MESRF 79-288

The particulate matter of thirty water samples collected near the Waterways Experiment Station in Vicksburg, Mississippi, have been characterized. The investigation included ten samples from each of three different locations: the Mississippi River, Yazoo River, and Brown's Lake. Characterization was conducted using particle size distributions, surface areas, scanning electron microscopy, differential thermal analysis, energy dispersive X-ray analysis, X-ray diffraction, and emission spectroscopy. Major differences were noted between all three powder populations.

AD
UNCLASSIFIED
UNLIMITED DISTRIBUTION
Key Words

Sediments
Water analysis
Particle size

Army Materials and Mechanics Research Center,
Watertown, Massachusetts 02172
POWDER CHARACTERIZATION OF WATERWAYS
EXPERIMENT STATION NMFC 196500 WATER
SAMPLES - Normand D. Corbin and
James W. McCauley

Technical Report AMMRC TR 81-9, February 1981, 18 pp -
illus-tables, Intra-Army Order MESRF 79-288

The particulate matter of thirty water samples collected near the Waterways Experiment Station in Vicksburg, Mississippi, have been characterized. The investigation included ten samples from each of three different locations: the Mississippi River, Yazoo River, and Brown's Lake. Characterization was conducted using particle size distributions, surface areas, scanning electron microscopy, differential thermal analysis, energy dispersive X-ray analysis, X-ray diffraction, and emission spectroscopy. Major differences were noted between all three powder populations.

AD
UNCLASSIFIED
UNLIMITED DISTRIBUTION
Key Words

Sediments
Water analysis
Particle size

Army Materials and Mechanics Research Center,
Watertown, Massachusetts 02172
POWDER CHARACTERIZATION OF WATERWAYS
EXPERIMENT STATION NMFC 196500 WATER
SAMPLES - Normand D. Corbin and
James W. McCauley

Technical Report AMMRC TR 81-9, February 1981, 18 pp -
illus-tables, Intra-Army Order MESRF 79-288

The particulate matter of thirty water samples collected near the Waterways Experiment Station in Vicksburg, Mississippi, have been characterized. The investigation included ten samples from each of three different locations: the Mississippi River, Yazoo River, and Brown's Lake. Characterization was conducted using particle size distributions, surface areas, scanning electron microscopy, differential thermal analysis, energy dispersive X-ray analysis, X-ray diffraction, and emission spectroscopy. Major differences were noted between all three powder populations.

AD
UNCLASSIFIED
UNLIMITED DISTRIBUTION
Key Words

Sediments
Water analysis
Particle size

—8